2/10

Do not write outside the box

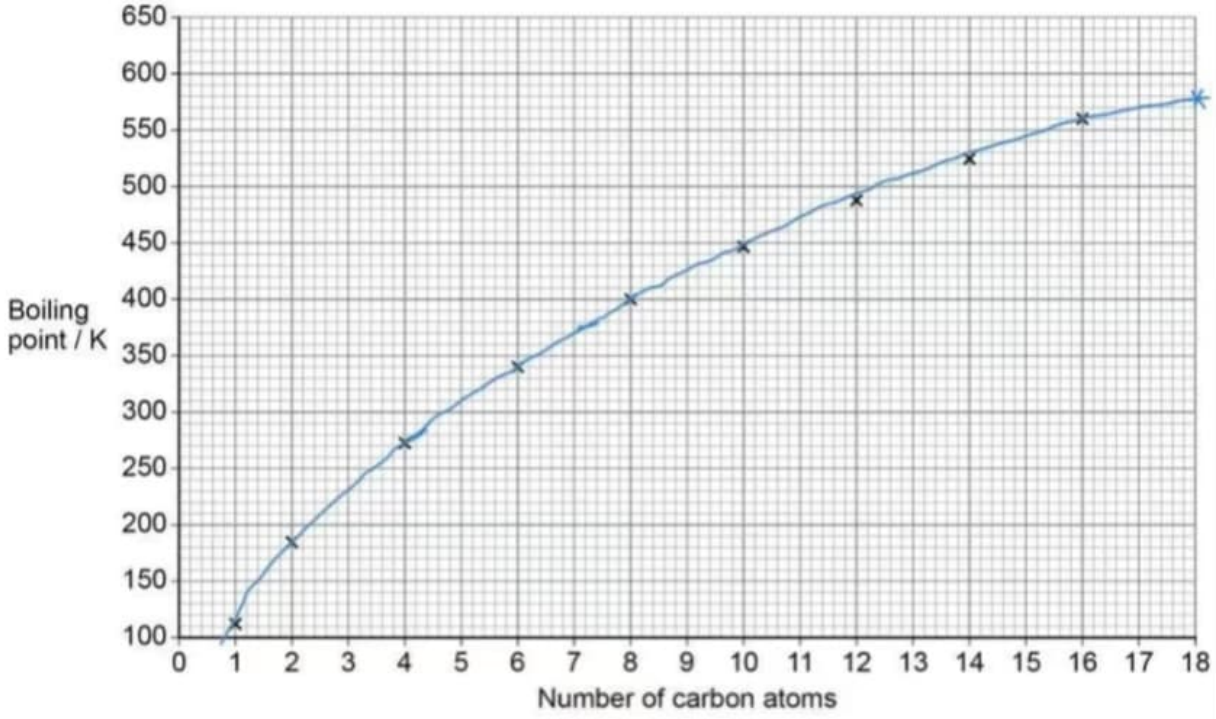
Answer **all** questions in the spaces provided.

0 1 This question is about hydrocarbons.

Figure 1 shows a graph of the boiling points of some straight chain alkanes.

Octadecane ($C_{18}H_{38}$) is a straight chain alkane.

Figure 1



0 1 . 1 Draw a line of best fit on **Figure 1**.

Continue the line to determine a value for the boiling point of octadecane.

[2 marks]

Boiling point of octadecane 580 K

0 1 . 2 Name a process that can be used to separate octadecane from a mixture of alkanes.

[1 mark]

fractional distillation

3/10

Do not write outside the box

Alkanes are burned in air in internal combustion engines of cars.

0 1 . 3 Identify **two** toxic gases that are formed in internal combustion engines of cars.

Write **one** equation to show how **both** toxic gases can be removed by a catalytic converter in these cars.

Identify the catalyst used in the catalytic converter.

[3 marks]

Toxic gases CO and NO

Equation

$2CO + 2NO \rightarrow N_2 + 2CO_2$

Catalyst Pt

0 1 . 4 Write an equation for the complete combustion of octadecane ($C_{18}H_{38}$)

[1 mark]

$C_{18}H_{38} + \frac{55}{2}O_2 \rightarrow 18CO_2 + 19H_2O$

0 1 . 5 Write an equation for the cracking of one molecule of octadecane to give one molecule of decane ($C_{10}H_{22}$), one molecule of pentene and one other product.

[1 mark]

$C_{18}H_{38} \rightarrow C_{10}H_{22} + C_5H_{10} + C_3H_6$

8

Turn over for the next question

4/10

Do not write outside the box

0 2 This question is about isomers.

0 2 . 1 Compounds **D** and **E** have the molecular formula C_4H_{10}
D has a higher boiling point than **E**.

Draw the skeletal formula of **D** and the skeletal formula of **E**.

[2 marks]

D

E

0 2 . 2 Compounds **F** and **G** have the molecular formula C_4H_8
Bromine water turns colourless when added to **F** but there is no visible change with **G**.

Draw a structure for **F** and a structure for **G**.

[2 marks]

F

G

0 2 . 3 Define stereoisomerism

[1 mark]

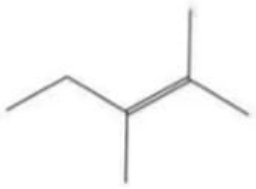
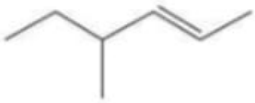
compounds with the same structural formula but different arrangement of atoms in space.

5/10

Do not write outside the box

0 2 . 4 **Table 1** shows the skeletal formulas of three isomeric alkenes.

Table 1

A	B	C
		

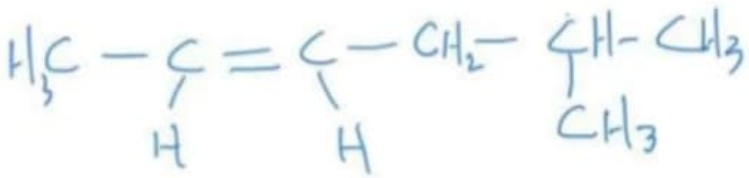
Tick (✓) **one** box to choose the alkene, **A**, **B** or **C**, that can show *E*–*Z* isomerism.

[1 mark]

A ☐ B ☐ C ☑

0 2 . 5 Draw the structure of *Z*-5-methylhex-2-ene.

[1 mark]



7

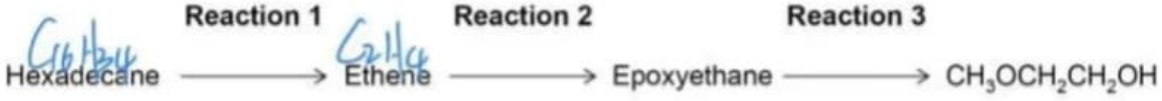
Turn over ►

6/10

Do not write outside the box

0 3 A reaction sequence starting from hexadecane ($C_{16}H_{34}$) is shown in **Figure 2**.

Figure 2



0 3 . 1 In **Reaction 1** the only products are octane (C_8H_{18}) and ethene.

Write an equation using molecular formula for **Reaction 1**.

[1 mark]

$C_{16}H_{34} \rightarrow C_8H_{18} + 4C_2H_4$

0 3 . 2 Write an equation for **Reaction 2**.

Show the displayed formula of epoxyethane in your answer.

[1 mark]

$C_2H_4 + \frac{1}{2}O_2 \rightarrow$

0 3 . 3 Name the catalysts used in **Reaction 1** and in **Reaction 2**.

[2 marks]

Catalyst in **Reaction 1** zeolite

Catalyst in **Reaction 2** Ag

0 3 . 4 Identify the substance that reacts with epoxyethane in **Reaction 3**.

[1 mark]

CH_3OH

5

7/10

Do not write outside the box

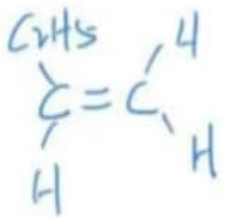
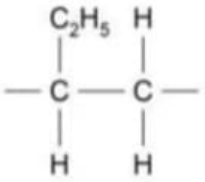
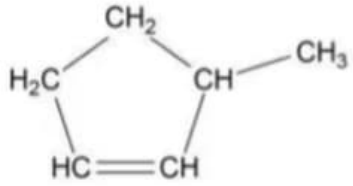
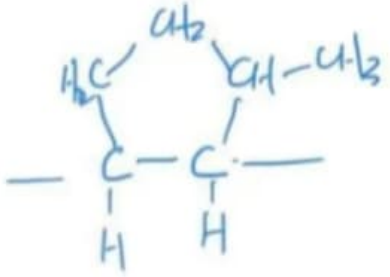
0 4 This question is about polymers.

0 4 . 1 Complete **Table 2** to show the

- structure of the monomer used to form polymer **K**
- repeating unit of the polymer formed from monomer **L**

[2 marks]

Table 2

Monomer	Repeating unit of the polymer
Structure of the monomer used to form polymer **K** 	Polymer **K** 
Monomer **L** 	Repeating unit of the polymer formed from monomer **L** 

0 4 . 2 State why polymer **K** in Question **04.1** is not biodegradable.

[1 mark]

C-C bond is non-polar. It is unreactive

8/10

Do not write outside the box

0 4 . 3 **Table 3** shows data from the analysis of a hydrocarbon.

Table 3

Element	% by mass
Carbon	88.9
Hydrogen	11.1

The mass spectrum of the hydrocarbon gives $M_r = 54.0$

Calculate the empirical formula **and** the molecular formula of the hydrocarbon.
Show your working.

[3 marks]

C H

mass in/100g 88.9 11.1

mole $\frac{88.9}{12} = 7.41$ $\frac{11.1}{1} = 11.1$

divided by the smallest number $\frac{7.41}{7.41} = 1$ $\frac{11.1}{7.41} = 1.5$

ratio 2 3

empirical formula C_2H_3

$\frac{54}{12\times2+3} = 2$

molecular formula C_4H_6

Empirical formula C_2H_3

Molecular formula C_4H_6

6

Turn over ▶

9/10

Do not write outside the box

0 5 This question is about rates of reaction of halogenoalkanes.

0 5 . 1 Define rate of reaction.

[1 mark]

change in concentration of reactants or product in unit time

A student investigates the reactivity of halogenoalkanes.

- The student adds a halogenoalkane to ethanol and sodium hydroxide solution in a test tube.
- The student warms the mixture in the test tube at approximately 60 °C
- The halogenoalkane is hydrolysed.

0 5 . 2 Suggest how the student should heat the test tube safely.

[1 mark]

use a water bath / electric heater

Nitric acid and silver nitrate solution are added to the test tube in Question **05.2** to form a precipitate.

The time for a precipitate to appear is recorded.

The experiment is repeated with other halogenoalkanes.

The rate of reaction for each halogenoalkane is calculated and the results are shown in **Table 4**.

Table 4

Halogenoalkane	Rate of formation of precipitate / s^{-1}
1	0.0042
2	0.0054
3	0.0087

0 5 . 3 State the halogenoalkane that reacts in the shortest time.

[1 mark]

3

10/10

Do not write outside the box

Samples of 1-chloropropane, 1-bromopropane and 1-iodopropane are tested in this experiment.

0 5 . 4 Suggest why 1-iodopropane has the fastest reaction rate.

[1 mark]

C-I bond is the weakest

0 5 . 5 Explain why these reactions are slower at a lower temperature.
You must refer to particles in your answer.

[2 marks]

fewer particles have $E \geq E_a$

less frequent successful collisions

6

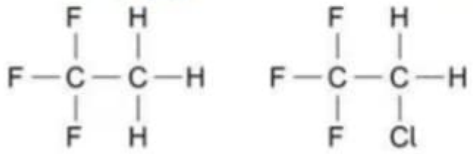
Turn over for the next question

2/10

Do not write outside the box

0 6 Compounds **M** and **N** are gaseous organic compounds.

$C_2H_3F_3$ $C_2H_2F_3Cl$



M **N**

0 6 . 1 Calculate the percentage by mass of fluorine in **M** (M_r = 84.0).
Give your answer to 3 significant figures.

[1 mark]

$\frac{3 \times 19}{84} \times 100 = 67.9\%$

Percentage by mass of fluorine _____

0 6 . 2 Suggest why **M** does not damage the ozone layer.

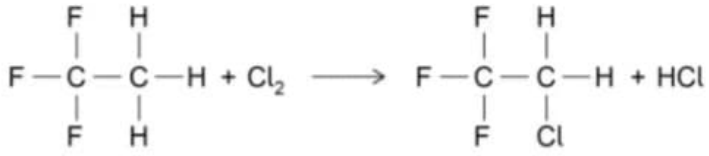
[1 mark]

C-F bond is stronger.

3/10

Do not write outside the box

M can be converted to **N** in the presence of chlorine and ultraviolet light.



M **N**

0 6 . 3 Name the mechanism for this reaction.

[1 mark]

free-radical substitution

0 6 . 4 2.64 g of **M** (M_r = 84.0) are reacted with chlorine.
The percentage yield of **N** is 93.0%

Calculate the mass, in g, of **N** formed in this reaction.

[3 marks]

mole of M = $\frac{2.64}{84}$ = 0.0314 mol

mole of N = 0.0314 mol

mass of N = 0.0314 × (12×2 + 19×3 + 2 + 35.5) × 93%

= 3.46 g.

Mass of **N** _____ g

0 6 . 5 A sample of **M** and chlorine are reacted in a sealed 10 dm^3 container at a given temperature and in the presence of ultraviolet light.

State why the rate of reaction will increase if the reaction is repeated in a 5 dm^3 container. V↓ P↑

[1 mark]

particles are closer together

frequency of successful collision ↑.

7

Turn over ►

4/10

Do not write outside the box

0 7 This question is about alkenes and halogenoalkanes.

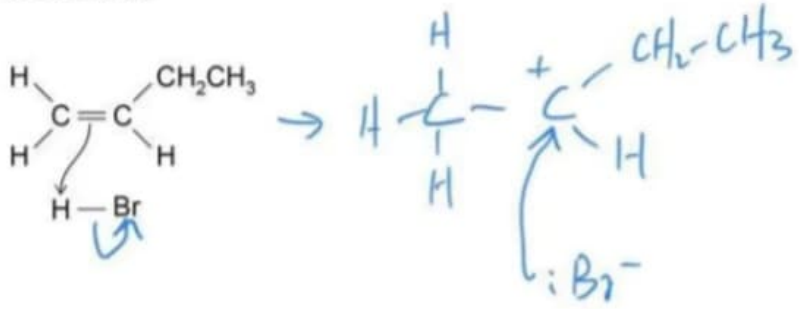
0 7 . 1 Alkenes react with hydrogen halides to produce halogenoalkanes.

Name and complete the mechanism to show the major product formed in the reaction between but-1-ene and hydrogen bromide.

[4 marks]

Name of mechanism electrophilic addition

Mechanism



5/10

Do not write outside the box

Halogenoalkanes can react under different conditions to make products with different functional groups.

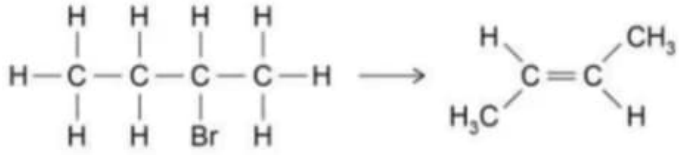
0 7 . 2 Give the meaning of functional group as applied to an organic molecule.

[1 mark]

an atom or group of atoms in an organic compound that determines the chemical properties of that molecule.

0 7 . 3 Give the reagent and **one** condition required for the following change.

[2 marks]



Reagent NaOH

Condition ethanol solvent

0 7 . 4 Give the reagent and **one** condition required for the following change.

Use IUPAC rules to name the organic product.

[3 marks]

Reagent KCN

Condition aqueous ethanol

IUPAC name of product 4-methyl pentane nitrile

10

Turn over ►

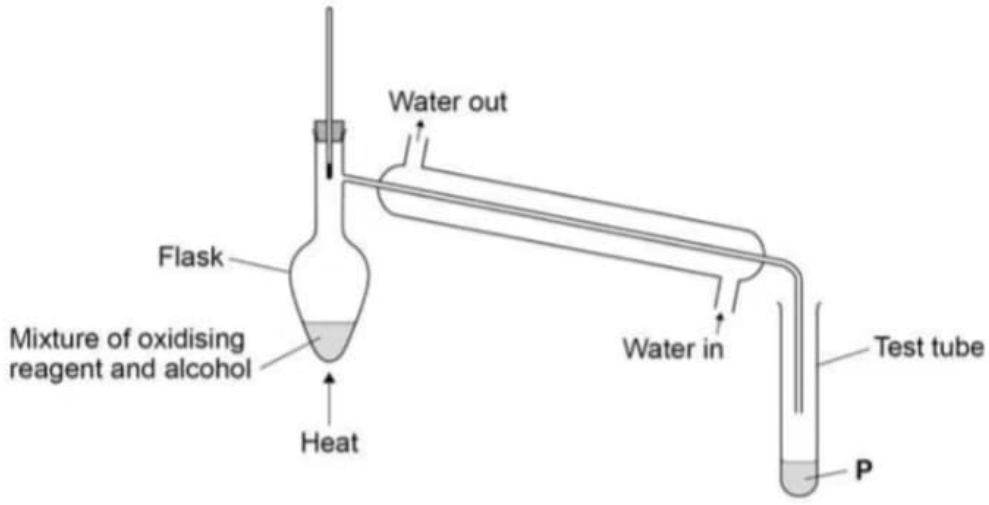
6/10

Do not write outside the box

0 8 This question is about alcohols and their oxidation products.

Figure 3 shows the equipment that can be used to oxidise alcohols.

Figure 3



0 8 . 1 Suggest one way to increase the yield of product **P** collected in the test tube in **Figure 3**.

[1 mark]

place test tube in ice bath

0 8 . 2 Name the practical technique used to obtain **P**.

State the reagent (or combination of reagents) used in the flask to oxidise the alcohol.

Describe the colour change observed in this reaction.

[3 marks]

Practical technique distillation

Reagent(s) acidified $K_2Cr_2O_7$

Colour change orange turns to green

Do not write outside the box

0 8 . 3 The carboxylic acid functional group can be identified by its reaction with aqueous $NaHCO_3$

Give the observation when propanoic acid reacts with aqueous $NaHCO_3$

Write an equation for this reaction.

[2 marks]

Observation effervescence

Equation

$CH_3CH_2COOH + NaHCO_3 \rightarrow CH_3CH_2COONa + H_2O + CO_2$

0 8 . 4 Identify the organic product of the reaction of 2-methylbutanal with Fehling's solution.

State what is observed in this reaction.

[2 marks]

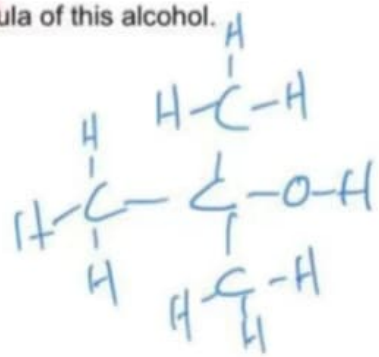
Organic product / 2-methyl butanoic acid

Observation blue solution turns to brick-red ppt.

0 8 . 5 An alcohol with molecular formula $C_4H_{10}O$ does **not** react with the oxidising reagents used in this question. tertiary

Draw the displayed formula of this alcohol.

[1 mark]



9

Turn over ▶

8/10

Do not write outside the box

0 9 This question is about the equilibrium

$$X_2(g) + 2Y(g) \rightleftharpoons 2Z(g)$$

0 9 . 1 A student adds 2.0 mol of X_2 to 3.0 mol of **Y**.
The mixture is placed in a sealed container at a given temperature to reach equilibrium.
The equilibrium mixture contains 1.5 mol of X_2

Complete **Table 5** to show the amount, in mol, of each substance at equilibrium.

[2 marks]

Table 5

	X_2	Y	Z
Initial amount / mol	2.0	3.0	0.0
change	0.5	1	1
Equilibrium amount / mol	1.5	2.0	1.0

0 9 . 2 The student repeats the experiment with different amounts of X_2 and **Y** at a different temperature.

At equilibrium, the concentration of X_2 = 0.150 mol dm^{-3}
and the concentration of **Y** = 0.0520 mol dm^{-3}
At this temperature, the value of the equilibrium constant, K_c = 290 mol^{-1} dm^3

Write the expression for the equilibrium constant, K_c

Calculate the concentration of **Z**, in mol dm^{-3}, at equilibrium.

[3 marks]

$K_c = \dfrac{[Z]^2}{[X][Y]^2}$

Calculation $290 = \dfrac{[Z]^2}{0.15 \times (0.052)^2}$

$[Z] = 0.143$

Concentration of **Z** _____ mol dm^{-3}

9/10

Do not write outside the box

Table 6 shows the value of the equilibrium constant (K_c) at different temperatures.

Table 6

Temperature / K	K_c / mol^{-1} dm^3
300	780
500	160
700	55

T↑ K↓

0 9 . 3 State how the equilibrium concentration of **Z** changes as the temperature increases.

Explain your answer.

[3 marks]

Change in equilibrium concentration of **Z** decrease

Explanation T↑ K↓ forward reaction is exothermic, equilibrium shift to the left to oppose the increase of temperature

0 9 . 4 The student repeats the experiment under different conditions.

Complete **Table 7** to state the effect on the value of equilibrium constant (K_c) and the position of the equilibrium when

- a catalyst is added
- the volume of the container is increased.

[2 marks]

Table 7

	Effect on K_c	Effect on position of equilibrium
Catalyst is added	no effect	no
Volume of the container is increased U↑ P↓	no effect	left

Question 9 continues on the next page

10/10

Do not write outside the box

The equilibrium is repeated here.

$$\mathbf{X}_2(g) + 2\mathbf{Y}(g) \rightleftharpoons 2\mathbf{Z}(g)$$

At 300 K, the value of the equilibrium constant, $K_c = 780\ mol^{-1}\ dm^3$

0 9 . 5 Calculate a value for the equilibrium constant (K_c) for the reverse reaction at 300 K **and** give the units for this K_c

[2 marks]

$\frac{1}{780} = 1.28 \times 10^{-3}$

$mol\ dm^{-3}$

K_c _____

Units _____

12

END OF QUESTIONS